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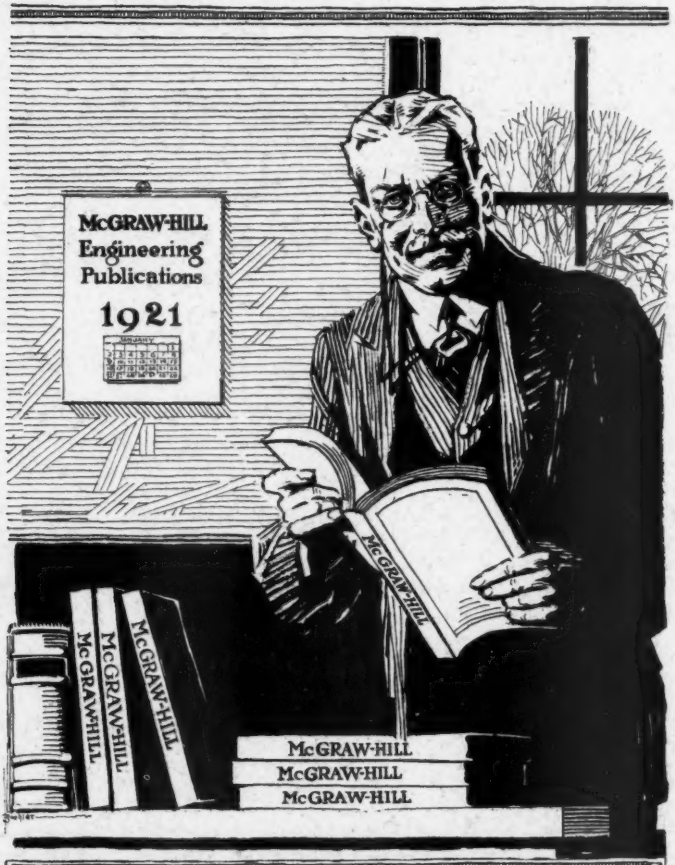

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BULLETIN

OF THE

Society for the Promotion of Engineering Education

Published under the supervision of the Publication Committee:

Mortimer E. Cooley, Arthur M. Greene, Jr., F. L. Bishop, *Editor*.

Address all communications to the Editor, University of Pittsburgh, Pittsburgh, Pa.

VOL. XI LANCASTER, PA., JANUARY, 1921 NO. 5

TABLE OF CONTENTS.

The Michigan College of Mines in the Nineteenth Century. M. E. Wadsworth 230
The Teaching of Surveying. Clarence T. Johnston 257
The Value of "g" in Engineering Work. S. A. Moss 271
Editorial 282
Obituary 284
College Notes 286

THE MICHIGAN COLLEGE OF MINES IN THE NINETEENTH CENTURY.

By MARSHMAN EDWARD WADSWORTH,

Dean Emeritus, School of Mines, University of Pittsburgh, also Director and President of the Michigan College of Mines from 1887 to 1899.

Ladies and Gentlemen: Alumni, Officers, Students and Friends of the College:

Since receiving the kind invitation of President McNair to address you, it has been necessary for me to live over again the early days of this institution or from 1887 to 1899, to think of her struggles, her misfortunes, her trials, and her triumphs. No such extended retrospect is possible without recalling many painful as well as many happy days. They were days filled with hard, ceaseless labor, care and anxiety, failures and successes, and were always occupied in studying over what could be done to advance the College, and to better train the students for future work.

It commenced a period when the school was in its weak and sickly infancy, a time when its death was momentarily expected, but it ended, for the School, in a strong and vigorous life, and it then stood amongst the famous mining schools of the world.

While the College has since increased in numbers, its policy, principles and methods have been practically unchanged. While Judge Hubbell was the undoubted father of the act that gave it birth, he was absent from this region during its early infancy, and its nursing and mothering fell upon the one who now stands before you, and who fought with all his strength to save it and to render it renowned.

It is impossible for one to be connected with the planning, arranging and developing a new institution of high grade, in

a mining community, whose interests were commercial, without meeting more or less obstructions and disagreeable events in the way. At this time, however, let us look at some of those things that have led to the development of this famous College, towards whose welfare so many have contributed, rather than to dwell much upon the obstructions, misunderstandings, misrepresentations and self seekings with which the pathway was strewn.

The Michigan Mining School, established by an act of the Legislature, approved May 1, 1885, first opened its doors to students on Wednesday, September 15, 1886, but in the meantime a Board of Control had been appointed, consisting of James N. Wright, Calumet, President; Thomas L. Chadbourne, Houghton, Secretary; Charles H. Cady, Iron Mountain; John H. Foster, Williamstown; Alfred Kidder, Marquette and John Senter, Eagle River. This Board was organized July 15, 1885, and later elected Allen F. Rees, Treasurer, and Albert Williams, Jr., as Principal. Mr. Williams selected John D. Hoffmann, as instructor in mathematics and drawing, and Robert L. Packard, instructor in chemistry.

Principal Williams announced that the school was to have a two years curriculum, which was to cover mining engineering, metallurgy, geology, chemistry, assaying, mathematics, physics, surveying, drawing and shop work, but the course was never laid out or published by him.

Mr. Williams, a graduate of Princeton, at the time of his election, was chief of Division of Mining Statistics and Technology of the United States Geological Survey, and editor of the valuable volumes of the Mineral Resources of United States. He was a very able, gentlemanly, and fine appearing man and a good writer.

Instructor Hoffman was a graduate of the University of Marburg, Germany, and had many years experience in mining engineering in California. Instructor Packard was a graduate of Bowdoin College, and excellent chemist and of a brilliant intellect.

The intent of the Board was to make the School one of

the most practical mining schools in the United States, something like the later established Wisconsin Mining Trade School, but the mistake made was the usual one of confounding the practical man with a practical educator. To teach any subject or to handle an educational institution requires a man who is experienced in, or born, fitted for that work. It can be said teaching and educational management require just as much practical experience in those lines, as it does to manage a mine, a stamp mill or a smelter in their lines.

The highest education in the world does not fit a man for the management of a college or university. He must be able to sympathize with his students, and his Faculty; to be honest and truthful with them, but firm with all of them. He must be a leader and not a follower. He must have the courage of his convictions, and follow them to the end, even to death.

In the case of the staff first selected, as above mentioned, to organize and develop the Michigan Mining School, none of the men had any practical experience in managing any educational institution or even in teaching, except Instructor Packard, who had some five years of instructional work. The result was that for the first year of the College there is nothing to show, except an elementary prospectus of ten pages, dated July 12, 1886, prepared by Principal Williams, and a joint report to the Legislature on the Michigan Mining School by the Committees on Mines, Minerals and Mining Interests of the Senate and of School of Mines of the House, made March 3, 1887, 24. pp.

This last pamphlet estimates the then equipment of the School at less than $4,500. The School was scheduled to be in session five hours a day, five days a week for 39 weeks. Principal Williams resigned in July, 1887, having been in charge about one year. The State Geologist, Charles E. Wright, of Marquette, was appointed on the Board of Control to succeed Mr. Cady, and Graham Pope, of Houghton, to succeed John H. Foster. Messrs. Kidder, Chadbourne and Charles E. Wright were appointed a committee to secure Mr. Williams' successor. Under date of July ninth, your speaker,

having then had a practical experience as an educator extending over 24 years, a graduate of Bowdoin and Harvard, a student at Heidelberg, was asked if he would accept the position, by Mr. Wright, who wrote: "You will have full swing in the school and will be responsible accordingly for its success." Mr. Wright had spent much of the winter of 1885–86 at Colby University, studying petrography under me, while our personal acquaintance had began many years previously.

Through some mischance the election was delayed until August seventeenth, although the term was to open September fifteenth. This gave but brief time to pack up my large library, move it to Houghton, and to close up the eastern work. With the utmost expedition, Houghton could not be reached until the night of September fourth. On the way, a visit made in Detroit, to the architects of the proposed new building, enabled me to change the plans so the unnecessary hall space could be added to the more useful class rooms and laboratories.

On September fifth it was ascertained that there was no course of instruction or plan for the next school year; that nothing had been done by any one to prepare for the opening of the new term; a new professor was to be found, as Instructor Hoffmann had resigned; and that Professor Packard was on the high seas, and no one knew where he could be reached; or when he would return. Collections, apparatus, and other means of instruction were to be procured; the course laid out; and things to be got in readiness as soon as possible; the old rooms needed to be remodeled, and new rooms provided; there were no records of the preceding year's work, nor list of the students that had attended; and outside of the two pamphlets mentioned, there was nothing to show what had been done. The Michigan Mining School's rooms then consisted solely of "Fireman's Hall" or the upper floor of the Houghton Engine House, with an undivided part of its basement, and for equipment the school had one chemical balance, a small muffle furnace, a small mineral collection, etc.

The School then was like a European trench, after a 48

hours' bombardment—chaos and with the new term only nine days away. Preparedness certainly had not been the watchword previously—simply waiting for "the new man on the job."

The general feeling of the community at that time was voiced by remarks made to me by Cashier James B. Sturgis, who said that the School was established as a political sop to the people of the Upper Peninsula; and that it could not and would not last over three years. Although Mr. Sturgis was a warm friend of the School and showed himself a good personal friend to me many times afterwards, it was determined, by the Director, to prove him mistaken, and to make the School what no other State School of Mines had then been able to be—a success. The problem was what could be done to make the institution one of high standing and second to none in the country—one that the Upper Peninsula, the State and the Nation should be proud of. On September fifth the pressing questions were what had been done the preceding year, and what could be done before the coming fifteenth.

It chanced that an able student of the preceding year was at hand, and by his aid the former students' names obtained, and the work of 1886–87 partially reconstructed and made available, not only for that time, but for the first catalogue of the School to be published in 1888. The College never should forget the aid, Houghton's townsman, Reginald C. Pryor, gave it at that critical period.

Most fortunately in looking for a professor of mining and engineering, a graduate of the class of 1886 of the Columbia School of Mines was found in a Houghton citizen, and Richard M. Edwards, became one of the first as well as one of the best professors the institution ever had. He was a born teacher, kind, tactful, thorough, energetic and firm. Too much credit can not be given him for his invaluable aid in the formative years of 1887–89.

In conformity to the German custom for similar schools and in accord with that of the Sheffield Scientific School of Yale, the title "Director" in preference to that of "Presi-

dent," was given the new head of the Michigan Mining School in accordance with his request. He then prepared the course, engaged additional rooms in the Odd Fellows building, had the old rooms remodeled, procured cases, collections, and opened the new term September 15, 1887. Later the term President was used, although one carried the same duties as the other. The reason for change was purely a business one, for experience showed that business men and many others confounded the term Director with that of a Director of a bank or corporation, thus leading to many mistakes and extra correspondence. In value, however, the two designations, so far as the Michigan College of Mines is concerned, are absolutely the same; the Executive and Administrative Head of the School.

At the time the Director took charge of the Michigan Mining School there were only two distinct State Schools of Mines in operation, besides the Michigan one, neither of which confined itself wholly to mining-engineering subjects. The Colorado State School of Mines was established in 1874, and in 1887–88 it had in all its courses 45 students. The Missouri School of Mines, with its preparatory and all its other departments, had in that year 52 students. There were ten or more Departments of Mines in connection with various state and other universities and colleges; but the numbers of students of mining in all of these, except Columbia and Lehigh, were less than those given above for Colorado and Missouri. Columbia had, in 1887–88, 51 students in mining, and Lehigh 56, Massachusetts Institute of Technology, 35, University of California 14, The College of Montana 12, Ohio State University 11, and the University of Wisconsin 2.

The way was dark and forbidding, and the remains of past failures could be seen everywhere. In truth, no distinct State School of Mines that was ever organized in the United States could be called successful up to that time. Success for the Michigan School could not be hoped for except through the locality of the school and a rigid adherence to principles to be laid down then, and steadily carried out. Locality alone

could not do this; there was also needed an organization that should attempt to save the good and avoid the evils of other institutions.

The main principles then formulated by the Director for the organization of the school were as follows:

1. To keep the School a special one for giving instruction in all branches relating to the development of the mineral wealth of the State and Nation, or a special school of mining, metallurgy and ore dressing, i.*e.*, a strictly professional school.

2. To give the very best, most practical and highest education in this field that it was possible to reach with the means at command.

3. That the instruction should always be by class room, laboratory and field methods, or a true union of theoretical and practical instruction.

4. That the School should, in its earlier days, put every dollar obtainable into equipment and collections for teaching purposes, and spend nothing for show, until the departments themselves were in a condition to do their proper and designated work.

5. That special opportunities should be given to men of mature or advanced age who had been engaged in practical work, and who wished to obtain an education to aid them in their subsequent labors. This was the Director's special wish since experience had shown him that but little encouragement was given to such students in some prominent schools of this country.

6. That the catalogues and other publications should state, so far as can be known in advance, the exact truth about the School and its instruction, which was done as far as possible.

7. That no one should be appointed an officer in the School, or be retained therein, for any other reason that his fitness for the place and his capabilities for doing his work. This rule was strictly carried out by the Director, although he may have been and probably was deceived by others, and thereby made mistakes. He never allowed his personal feelings to enter the

question but the good of the School was the one thing always sought by him.

8. The students in the school must work or leave; and that no distinction should be made among them on account of their worldly wealth or honor, or birthplace—the only criterion should be their ability to perform their duties. Also that quality and thoroughness of work should be the aim, and not mere numbers of students. Their retention in the School was made dependent upon their daily work and their public behavior, for no attempt was made to spy upon them in any way. No student was ever asked to betray another, and all were assumed to be honorable men until they proved themselves that that view was erroneous. The authorities of the twin towns were requested to deal with student offenders as they would with any others, and not to shield them in any way.

9. That the institution should be managed on business principles, and the professors be allowed to conduct their departments according to their own individualities. They should be held responsible for producing the required results, but not for their methods of bringing about these results. They should have entire choice and direction of their subordinates, who were to be solely responsible to them. Further, that the professors should receive from the Director every aid and assistance possible in the developing of their departments, and that they should be supported in enforcing proper discipline. In doing this, often to protect the professor, the Director was repeatedly blamed for the delay and neglect of others.

10. That the school should be conducted for the benefit of the students and of the State and Nation, and not for the particular advantage of the town in which it happened to be located, or for any special clique. This was done in the belief that in serving the State best, the local towns will in the end be more benefitted than by any other policy.

In the development of the school there were naturally many factors concerned, like the local communities, the people of the Upper Peninsula and those of the Lower, the belligerent

and diverse state educational school interests, the Board of Control, the Faculty and other officers of the School, and last but not least the Students and Graduates. All these had their varied interests and naturally worked towards the end they sought—whether it might be for their gain, or for the good of the School. Of the 15 members of the Board of Control, during these 12 years, a remarkably good selection was made. The members were business men, engineers, managers, politicians and lawyers, and as a matter of course looked at the school problems through the light of their own views, none of them having had experience in educational management.

Of those who took a most active part in the School's affairs then, may be mentioned Messrs. Chadbourne, Kidder, Wright, Pope, Longyear, Hubbell, West, Dunstan, Kelly and Brown. Of two of those, Mr. Kidder served during the entire time of the Director's term and Mr. Longyear all but the brief period that State Geologist Wright was on the Board. No man could ever ask for more helpful, broader minded men, or who understood better the problems the Director had to contend with. Judge Hubbell was devotedly interested in the School, and labored for what he believed was for its good, but he naturally viewed it, as did Lieut. Gov. Dunstan, from the politician's standpoint. With the Director working as an educator from the view point of what would be best for the School and its students, he could but traverse some of the views of those excellent men. However, differences as to what was best for the School ought not to imply personal antagonism.

The Director has no doubt in his efforts to develop the School, whose necessities were then so little understood, that his direct methods of going after what was needed, must have been annoying to those busy men, to whom the School was an added burden, and that as Judge Hubbell afterwards put it: "He is persistent. Yes!——persistent."

The school year was then of 39 weeks, the attendance in 1886–87 was 23, in 1887–88, 29. At the close of this last year the first class of seven, graduated with the B.S. degree, and all

but one, who died young, have made excellent reputations and reflected credit upon their Alma Mater: Harris, Longyear, the two Parnalls, Seager, and Uren.

In the spring of 1888 the School sustained a great loss in the untimely death of Charles E. Wright, State Geologist, and member of the Board of Control. Earlier Mr. Wright in his arduous labors on the State Geological Survey had developed a severe cardiac difficulty, but in spite of all remonstrance he continued his Survey work enthusiastically. He passed much of the winter in 1887–88 in Baltimore, returning home to die of broncho-pneumonia March 22. His death was keenly felt by the Director as it removed the only intimate friend, he then had, in the Northern Peninsula. At the insistence of Mr. Wright's friends, the Director was appointed State Geologist and reluctantly took up those extra duties.

In the summer of 1888 the rooms in the Odd Fellows hall were given up and new rooms taken in the then Roller Rink Building, later known as the Armory Opera House, which was occupied during the school year 1888–89.

In the catalogue for 1888–89 the two years' course remained in effect for all students entering prior to 1889, but of all admitted that year, the three years' course was required. That year the term was 37 weeks long, the attendance was 40, and faculty increased by the addition of Messrs. Sharpless, of the University of Michigan, and Pryor, of Houghton.

The erection of State Hall, afterwards called Hubbell Hall, was commenced in 1888 and was occupied in May, 1889. The fall of 1888 saw the preparation for the meeting of the Legislature in January, 1889. At this time a friendly, but strong, difference of opinion developed as to the attitude to be taken in approaching the coming Legislature. The Secretary of the Board, Mr. T. L. Chadbourne, a man of honor, high ideals, and unquestioned probity, on one side, believed that the requested appropriation should be small, not over $25,000 or $30,000 at the utmost; while on the other hand the Director advocated that the School should ask according to its needs, leaving the

curtailment, if any, to the Legislature. This proved to be the turning point of the School. The views of the Director prevailed, and as result $104,000 were appropriated, of which $60,000 were for the equipment of Hubbell Hall. The successful work in obtaining the appropriations was largely due to Gov. C. G. Luce, who proved himself a better friend to the College, the State Geological Survey and to the Director, than any other governor during your speaker's term of office.

Besides his duties as professor in the School, the Director as the general executive officer, under the Board of Control, had the management and charge of the School, its courses, its officers and students, its buildings, its relations to the public, to the Legislature and to the State, the looking up and recommending for employment, and discharge of all of the professors, instructors, and other officers of the School, and the protection of its interests. He had to prepare the catalogues, defend the School in the public press, and endeavor to make it widely known.

During the earlier years all the correspondence of the School, stated then by the postmaster to be the largest of any in Houghton, had to be carried on by the Director without any clerical help from the institution, until the summer of 1889, when a clerk was first employed. All purchases, estimates, bids, including most of the equipment of the buildings, reports to the Legislature, etc., devolved upon him until 1890. Until the fall of 1889 all the records of the Faculty were kept by him. The enormous amount of labor of all these manifold duties crowded upon him, can not be estimated or even understood. All day and late at night, often all night, he was engaged upon the school work. The result of this labor was a complete break down of the Director from overwork, in the winter of 1888–89, and for a long time his death was expected. From this illness he did not completely recover until the summer of 1890.

Fortunately in the summer of 1889 the Director was able to procure the services of Dr. A. C. Lane, from Harvard, Heidel-

berg, and the United States Geological Survey, afterwards State Geologist, as an instructor; Robert I. Rees, as an able and efficient clerk. Mr. Rees, later entered the Army as a private, but rose to be a Brigadier General, in charge of the educational work, during the late war; also A. E. Seaman, as an assistant, and the faithful and incomparable Henry Gibbs. Seaman as an instructor and professor is known and loved by every graduate of the school and who does not know and esteem Gibbs?

In the summer of 1889 there were six graduates: Croze, Farwell, Fesing, Haas, Hoatson, and Pryor.

Owing to the introduction of the three years course and the increase in the requirements for admission the attendance was reduced to 35 in the year 1889–90, but in the end the wisdom of making the advances in the requirements was vindicated. In this catalogue the 45 weeks a year, or the so-called continuous year was inaugurated in the fall of 1889, for the purpose of making the course practically the equal of a four years course. While the credit for the continous year is ordinarily given to the University of Chicago, and not to the Michigan College of Mines, to which it belongs, this is not correct, as Dr. William R. Harper was chosen the first President of that University September 16, 1890, and did not accept until February 16. 1891, entering upon his duties July 1, 1891. The University of Chicago was not opened for students until October 1, 1892, or three years after the Director had inaugurated the practically continuous year in the Michigan College of Mines.

At the Michigan School the increased time of the School year was provided for by giving the instructors their vacations at different seasons of the year, instead of, as is customary, all at one season. From this the change could be made and was made without adding to the instructional staff.

In preparing the courses of the School, it was the Director's habit to ask the practical mining men: "What do you wish your son to know when he graduates?" and "If you desire to employ any graduate, what do you wish him to know?"

On the Director showing a course, he had laid out, to Mr. Whiting, then General Manager of the Calumet & Hecla, Mr. Whiting stated that it was the best and most practical one he had seen. President Alexander Agassiz, of the Calumet & Hecla, also said to Hon. Jay A. Hubbell, that they had employed men from every technical school in the country and that those from the other schools took from three months to a year before they were of value to the company, but that those from the Michigan School were useful from the start.

It was very unfortunate for the school that in January, 1890, Professor R. M. Edwards resigned to accept the important position of mining engineer for the Tamarack, Osceola and Kearsarge mines; but luckily the Director was able to secure as his successor a very valuable man in Professor F. W. Denton, a graduate of the Columbia School of Mines, and an instructor in that institution. In the summer of 1890 the Director further secured the services of Professor A. E. Haynes, of Hillsdale College, in mathematics and physics. H. F. Keller, of the University of Pennsylvania, in chemistry, and Edgar Kidwell, of the same University, in mechanical engineering and drawing.

The summer of 1890 saw the school firmly established as a constituent part of the higher education of the state of Michigan never to be uprooted or destroyed. The grade and character of its course and instruction, the standing and devotion of the Board of Control, the excellence of its Faculty and of its Students and Alumni, all enabled it to defeat every subsequent attempt to destroy it. Very much, hard work was yet to be done, but all unwittingly to its enemies, the untiring labor of the past, had rendered the School, as a School, forever secure.

Up to that time, its enemies could and would have destroyed it, had they understood what was being so quietly done by the Director, but knowing its history for 1886–87, and the general fate of such schools, they never dreamed that "Hubbell's folly," as they termed it, could have but one ending. Meanwhile with hard and incessant labor, the foundations of

the School were laid broad and deep, with out any flourish of trumpets or any intimation to the public of the work that was being done.

So ignorant then were the people of the Lower Peninsula of the School and its location, that prominent firms in Detroit, with which the Director tried to do business, actually sent the goods, and their letters for the School to Marquette, 95 miles away; and it took much energetic correspondence before they could understand where Houghton was located on the map. In truth no satisfactory business relations could be had with the Detroit houses at that time. It can be truthfully said that this school has done more to make Houghton known all over the world than has all of its mining interests.

So little was then known of the results of the noiseless work for the School amongst educational and political circles, that a prominent member of the Faculty of the Massachusetts Institute of Technology, and a long time friend, visiting the Director, told him that it would be impossible for him to do anything with the Michigan Mining School, that he could not compete with the other mining schools and that it was folly to try; also that the only thing open to the School was to make it a fitting school for the Massachusetts Institute. This was claimed at the time when the attendance of mining students at the Michigan School was much greater than that at the Massachusetts one.

For the school year 1890–91 the results of the appropriations of 1889, had enabled suitable equipment to be obtained, and the value of the increase of the course and its entrance requirements, became apparent, for the attendance rose to 65, or the largest number then, of mining students in the schools in United States—a wonderful result considering the condition of things in 1887–88.

In the 1890–91 catalogue a projected four years' course was laid out by the Director, with the aid of the Faculty, that it was expected to introduce in 1893, intending it to be, with the 45 weeks a year, the equivalent of a five-year course.

At the general election in the fall of 1890 a complete polit-

ical overturn took place, and the committee of the Legislature of 1891 was directed to look into the question of the early closing of the School. The feeling was so strong and bitter in the Lower Peninsula against the School, that the Director was assured by prominent members of the Committee that they were elected to the Legislature for the express purpose, as their constituents put it "to shut up that ——— mining school." But by the blessing of Almighty God when "the rain descended, and floods came, and the winds blew, and beat upon that house; and it fell not: for it was founded upon a rock," in the hearts of the people of the Northern Peninsula.

It was then that the wisdom of getting and putting into the equipment as much as was possible, when the "getting was good," was shown; also the provision for educating students of age and experience, the building up the educational standard of the School, and the strengthening of its Faculty. Perhaps one of the most useful things had been the assisting to a practical education of men of age and experience, for the people saw that men, who had worked side by side with them for years, had rapidly risen to positions of responsibility, power, and influence through the aid, the Mining School had freely given them.

The people of the Northern Peninsula, rallied as a unit, to the support of the School, and the chairman of the Legislative Committee was told by the leader of his party, in this district, that if he dared to touch the School, his party would never again have a single vote north of the Straits of Mackinaw. It was readily shown the Committee that here was a fairly well equipped school, that was doing a useful work, and that the value of its property in 1890 was estimated at over $153,000, or more than the appropriations of $135,000 for building and equipment then given it. No weak spot was found. It was shown it had won name and fame, that it had more mining students than any other school in United States, and that it then had students from England, and Canada, and from seven states in the union, besides those from Michigan.

The legislative leaders told the Director that their party

was opposed to higher education, but since the School had been established and was in such an excellent condition, they would give it the necessary running expenses, but nothing for expansion. As a result, however, the Director obtained $72,600 for the biennial appropriation, or $57,600 for running expenses and $15,000 for equipment.

In 1891–92 the Director was able to secure for the School the services of Drs. Hubbard, of Harvard and Bonn Universities, and Patton, of Princeton and Heidelberg Universities, and the attendance increased to 78, while it was stated the four years course of 45 weeks each year would be definitely put into operation in 1893 instead of the three years course of 45 weeks then in use. The resignation of Dr. H. F. Keller in 1892, to accept a professorship in Philadelphia, was a very great loss to the School. He was an excellent teacher, earnest, capable, and trustworthy, and possessed of good executive ability. Dr. George A. Koenig, of the University of Pennsylvania, was obtained as Dr. Keller's successor. Dr. Koenig at that time was probably the best and most noted mineral chemist in United States. Owing to the change to the three years' course for all the students, there was no class to graduate that year in the older two years' course.

In 1892–93 the attendance rose in the three years' course to 101, but no students were allowed to enter after 1902, except in the four years' course, unless they were prepared to graduate with the class of 1905, the last class to graduate in the old three years' course of 45 weeks yearly. Students graduating in that course received the B.S. degree. The first three years of the four years' course, was identical with the three years' course, so as to save difficulties in the transition from one course to the other. In the fourth year, five electives were allowed, but the rest of the course, like all the others up to that time in the school, was strictly rigid. Students graduating in the four years' course were to receive the E.M. degree. This course required in the laboratory, field or class room some 6,950 hours, while the time for outside preparation was not estimated. This was so far as known the hard-

est four years' mining course ever put into operation in United States, if not in the world.

This year 1893, saw two new members of the Faculty added who have had a great influence upon the subsequent work of the school. On recommendation of Superintendent Robinson, of Detroit, the Director obtained Miss Frances Hanna, of that city, afterward Mrs. Frances Hanna Scott, as Librarian and Secretary, in which position she proved invaluable and of the greatest assistance to the students.

Professor Haynes, having been offered an excellent position at the University of Minnesota, as the result of his good work here, and previously, the Director selected as his successor Professor Fred W. McNair, of the Michigan Agricultural College, afterwards the second President, who proved himself a splendid instructor and a good disciplinarian.

Owing to the introduction of the four year course, the usual result followed, and the attendance diminished to 82. Experience soon showed that this course which required from seven to ten hours a day, five days a week, for 45 weeks a year, for four years in the class room, laboratory, and field, was too severe for the average student, especially when all his prepratory study had to be done in time outside of the some 7,000 hours.

The Faculty members were unanimous that something must be done, but what no one could suggest, as none of them were willing to return to any shorter course, or to drop any of their work, thereby shortening the required daily grind. The time could have been extended to five years, but at that early period, it would have depopulated the School.

After the Faculty had been canvassed in vain for some solution, the Director asked each one what he would think of an elective course. No one favored it, and as Professor McNair said: "I do not believe you, nor any one else can formulate an elective system that will meet our needs." However, he and the others agreed not to oppose the Director, if he could make out anything satisfactory. After some months' work, consulting individually daily with each of the

Faculty members and meeting their objections, the Director prepared an Elective System that was adopted unanimously by the Faculty and the Board; and was accepted by every student, when he was allowed the option between continuing on in the rigid four years' course, or transferring over to the course in the Elective System.

This Elective System was unique and the first ever prepared for any engineering school, and it has been in use here ever since, with only slight modifications. By modifications of its details, without affecting its principles, it can be made to cover every variation possible that the College may desire, even if it should expand into a University. By substituting abreviations like Mat. for A, Phy. for B, and so on, there is no limit to the list of subjects new or old, that can be made, the required subjects can be increased at will, and the difference between the B.S. and E.M. degrees made strongly marked. Owing to the then demand that there should be no duplication of the general work of the University of Michigan, all languages and general studies were omitted—now they can be added as needed.

At the time the Elective System was introduced, the Director discarded the old rules of Faculty meetings and government, which have always been, in every school, with which he has been acquainted, a source of serious trouble, arraying the Student Body against the Faculty. In its place he introduced a simple form of government in which the student performed his own decapitation by rule and instead of wasting time in general meetings of the Faculty, all matters were attended to by the members of the Faculty directly concerned, with the Director, or a government of consultation. The result of the introduction of the Elective System and its corresponding rules seemed to the Director like a new heaven and a new earth. The students cordially worked with the Faculty and assisted greatly in disposing of obnoxious and indolent students, while not a murmer was heard.

At the time of the introduction of the Elective System, it was intended by the Director, as soon as the School had

progressed far enough, so it could be done, that the B.S. degree should only be given to those students, who from ill health, lack of means or time, or for some other cause could only take the three years' course of 45 weeks each year, or the equivalent of the average four years' course of most colleges and universities. This degree would thus be given to but very few, and mark a lower order of work.

In the same way it was intended, as rapidly as possible, to have the majority of students, graduate in the four years' course of 45 weeks each year, or the equivalent of a five years' course in the average college and university. From beginning to end, as the catalogues and publications show, it was ever the purpose of the Director to push up higher and higher the requirements, the work and the graduation in the Michigan College of Mines.

No matter how the regulations are written, or arrangements are made, the results will depend upon the spirit, interest, sympathy and purpose in which they are carried out, by the various persons who have charge of their observance, advance and execution.

In 1894, Professor Denton, who had done excellent and valuable work for the school, resigned to go into private practice, and Professor F. W. Sperr, from the State University of Ohio, was recommended by the Director as his successor. In 1895 James Fisher, one of the Mining School's graduates, became an assistant in the School, and Albert J. Houle, another graduate, an instructor in 1896. For 1894–95, and 1895–1896, the attendance rose to 94.

At the meeting of the Legislature in 1897 in defference to the view published in the Proceedings (1895 Vol. III, pp. 25–46), of the Society for the Promotion of Engineering Education, that schools of this grade should be designated as colleges, the Director recommended that the name should be changed from the Michigan Mining School to the Michigan College of Mines; and for business reasons and the general misapprehension by the public of his duties, the Director's title be changed to President as previously explained. There

was at that time much complaint, on the part of the people of the Lower Peninsula and by members of the Legislature, that it was not fair to educate the students of other states and countries on the same terms as those of Michigan. This policy was considered objectionable by Governor John T. Rich, in his message to the Legislature, January 3rd, 1895. There was much justice in this, as in 1896–97, the attendance was 140, including students from Germany, British Columbia, Ontario, Cuba, Mexico, Scotland, and South Africa, besides those from 16 of the United States, other than Michigan.

To meet these complaints, to assist the College, to remove some of the burden from the tax payers of the State, and to cause the students from outside of the State, as well as those of our own State to appreciate what they were receiving from the College, the President recommended the Legislature to require the Board of Control to charge higher matriculation, tuition and laboratory fees. All the above having passed the Legislature and been approved, the President prepared with the assistance of the Faculty, the scale that went into effect for all students entering after August 26, 1897, but which has in many cases been changed in accordance with subsequent experience. Naturally the great increase in the expense to the students by this action cut down their number in 1897–1898 to 122, and in 1898–99 to 116.

Having always preferred the quiet life of a professor, instead of the more stormy and arduous one of a college president, seeing that the Michigan College of Mines was now in a safe harbor, and knowing that since it had become a valuable prize, the usual scramble for spoils would inevitably take place, the President wrote his resignation in 1897, and only refrained from presenting it then to the Board of Control by the remonstrances of the Faculty, particularly those of Professors McNair and Kidwell. The labor of writing it was not lost however, as with but little change it was available in the school year 1898–99.

The resignation of Professor Kidwell, in 1898, was a very serious loss to the institution. He was a superb teacher, a very

energetic man, and an excellent disciplinarian. His health had been greatly impaired by the confinement of a professorial position and his extremely hard work. He had been of the greatest assistance to the President and the College, but he felt that a more active outdoor life would be better for him, so he took the superintendency of a mine. Professor O. P. Hood, of the Agricultural College of Kansas, was selected as Professor Kidwell's successor, being recommended by the President to the Board, on account of the excellent work he had seen him do in the class room. George L. Christensen was selected to assist him, as they were friends and associates.

In looking over the names of the officers in the last catalogue —1896–1898—the President then issued, one sees those whom you all know: Koenig, Sperr, Hood, McNair, Seaman, Mrs. Scott, Fisher, Christensen, Houle, Gibbs, and the faithful Morin. Except for the later loss of Koenig and Hood, it seems even now as if it was almost the same old "bunch." Professor Carson is the only new Faculty member. Of the old Board of Control but one remains: Your chairman Hon. William Kelly, is a man of whom I have most pleasing recollections and for whom I have the highest respect. I have always had the deepest interest in the College, its Faculty, its Alumni, men of mark in the mining world, and it Students and the warmest wishes for their success. I do not know when I have had a pleasanter afternoon than when I accidentally met Instructor Cunningham last spring, although I had never seen him before. This gave us a chance to talk over the College and its belongings. The old graduates are of course my children and I love them, but new or old I am always glad to see any one who has to do in any way with this dear institution.

President Drinker, of Lehigh University, at the Anniversary of 1911 said to me: "If I could win the love and respect of my students, that your old students show for you, I would feel that I had accomplished the greatest and best work in the world."

The President's resignation took effect May 15, 1889, and

Professor McNair was elected his successor as President to take effect at that time.

The President stated in substance in his resignation: That when he took charge of the College in 1887 it had no organization or course of study. That since then he had prepared and put in operation successively two, three and four years' required courses, and later originated and introduced a complete Elective System adapted to the needs of the College.

The instruction directly under his charge had been systematized, and valuable working collections obtained and arranged, nearly thirty professors, instructors, and other employees were on the staff, for the last seven years over eighty students had been present each year, the number running up as high as one hundred and forty, and averaging one hundred and six while one hundred and ten men had been graduated during his term of office. Three large and three small buildings had been erected and equipped; the College property increased until it amounted to some $253,000.00, and all the departments well organized.

When he came to take charge of the institution, it had no hold anywhere, and its death was hourly expected. He left it firmly established, a recognized part of the great educational system of the State, a College that ranked with any in the world of its kind, and with many of its Alumni leaders in their chosen field. The College was then successful, prosperous and of world fame. No mining engineering school in United States ever had at that time, such a phenomonal growth in numbers and standing as this one had, and that, too, under extremely disadvantageous circumstances.

He thanked his numerous associates who had endeavored to so faithfully assist him and also the members of the Board of Control who had aided and sustained him, for to them belonged all due credit, as without their assistance he could have accomplished nothing.

The above address was delivered in Houghton, Michigan, August 10, 1916. The explanation of this late publication is that the editor of the local (Houghton) paper asked for a

copy of the address for publication. This was handed to him, and was published by him without any proof being sent to the writer. The result was, as is usual with a type-setting machine—numerous errors and elimination of any sense in many places. The publication was such that the writer, except in a few cases, was ashamed to make any use of it, and decided to revise it for another publication. One has, however, to be at the mercy of circumstances, and it so happened that some two days before the address was given, the weather changed suddenly from very hot to cold, and the writer caught a severe cold and was attacked with neuritis, so that he could only walk with difficulty, and could not well stand, without support, to deliver the address.

This neuritis kept almost constantly active for nearly four years and only allowed walking with extreme difficulty, made almost all work arduous, and in April, 1917, so affected the sight of one eye, that it was rendered useless. The evil effects of the neuritis still exist and the writer has not felt able to enter upon the revision of the address and attend to its publication until November of this year.

Since the above was given before a mixed audience of the citizens of the mining regions of the Northern Peninsula, besides the Board of Control, Faculty, Alumni and Students of the Michigan College of Mines, it was necessary only to touch upon the general progress of the College, and not to detail the reasons for the various steps. Owing to the causes for so unique a course in a technical college, having been generally misunderstood and misrepresented, it has always been the purpose of the writer to give the reasons and principles for so original procedures, as those in the three Schools of Mines of which he has had charge. His work, his general ill health, and his labors upon other writings has thus far prevented its completion.

The following publications have been prepared to a greater or less extent by him:

"The Number of Students and Graduates in Schools of Mines in the United States from 1863 to date."

"Some Experimentation in Mining Education, 1887–1912."

The following past publications by the present writer give more or less information regarding the Michigan College of Mines from its origin and the practical development that it had reached in 1899.

Circular of the Michigan Mining School, *The Copper Herald*, November 2, 1887.

The Work of Charles E. Wright, late State Geologist, in Science and Education. *The Marquette Mining Journal*, March 24, 1888.

First and Second Annual Catalogues of the Officers and Students of the Michigan Mining School, Houghton, Michigan, 1886–1888. 52 pages.

Third Annual Catalogue of the Officers and Students of the Michigan Mining School, Houghton, Michigan, 1888–1889. 55 pages.

Catalogue of the Michigan Mining School, Houghton, Michigan, 1889–1890. 72 pages, 1 table.

"Is it not a Mistake?" *The Daily Mining Journal*, 1891, No. 2222, p. 3, August 3.

Report of the Director and Treasurer of the Michigan Mining School, Houghton, Michigan, 1886–1890. 8 tables, 148 pages.

Catalogue of the Michigan Mining School, Houghton, Michigan, 1890–1891. 102 pages 11 tables, 1 map, 4 plates.

Report of the Director of the Michigan Mining School for 1890–1891. 59 pages.

Catalogue of the Michigan Mining School, Houghton, Michigan, 1891–1892. 175 pages, 9 tables, 6 plans.

Michigan Mining School. Report of the Supt. Pub. Inst., 1890, pp. 266–295, 3 tables.

Sketch of the Michigan Mining School, in History of Higher Education in Michigan, by Andrew C. McLaughlin, 1891, pp. 116–123.

Michigan Mining School, Report of the Supt. of Pub. Inst., 1891, pp. 125–134.

The relation of the Alumni to the Michigan Mining School. *Portage Lake Mining Gazette*, 1892, June 2, XXXIII, No. 45, p. 1.

Report of the Director of the Michigan Mining School for 1891–1892, 1893, pp. 102, 2 tables.

Michigan Mining School, in Michigan and its Resources 1893, pp. 144–148.

Michigan Mining School, in Report of Supt. Pub. Inst., 1893, pp. 281–298.

The Michigan Mining School, State Teachers' Association, 1893–1894, pp. 14; *The State Republican*, 1893, December 29, Vol. 41, No. 4947, p. 1.

Report of the Director of the Michigan Mining School, 1893–1894, in the Report of the Supt. of Pub. Inst., Michigan, 1894, pp. 380–383, 2 tables.

Education and Educators, Class Address, Lake Linden High School. *The Native Copper Times,* 1894, XI, No. 31, p. 3.

Catalogue of the Michigan Mining School, 1892–1894, 1894, 214 pp., XIII tables, 1 map, 11 plates.

The Michigan Mining School Appropriations, in *The Mining Journal,* Marquette, Michigan, 1895, February 12, No. 3314, p. 2.

"What Shall I Do?" *The L'Anse Sentinel,* 1895, Vol. XV, pp. 1, 8.

Prospectus of Elective Studies in the Michigan Mining School, 1895, pp. 50, 2 tables.

Annual Report of the Director of the Michigan Mining School, August 16, 1895, 14 pp.

The Elective System as Adopted in the Michigan Mining School. *Proc. Soc. Prom. Eng. Ed.,* 1895, III, pp. 92–100.

The Elective System as Adopted in the Michigan Mining School. *The American Geologist,* 1895, XVI, 223–228; *Eng. and Min. Jour.,* 1895, LX, pp. 224, 225.

The Relation of the Michigan Mining School to the High School. *Portage Lake Mining Gazette,* May 7, 1896, Vol. XXXVII, No. 44, p. 1.

The Michigan Mining School. *The Michigan Farmer,* 1897, XXXI, pp. 234, 235; 254, 255.

The Michigan Mining School. *Ontonagon Herald,* 1894, XII, No. 40, p. 2, January 20.

Report of the President of the Michigan Mining School for 1896. Ann. Rept. Supt. Pub. Inst., 1896, pp. 11.

Catalogue of the Michigan Mining School, 1894–1895, 1896, pp. V–284, 13 tables, 1 plate, 1 map.

The Elective System in Technological Schools. *Proc. Soc. Prom. Eng. Ed.,* 1895, pp. 14.

The Elective System in Engineering Colleges. *The American Geologist,* 1896, XVIII, 282–289.

The Elective System in Engineering Colleges. *Proc. Soc. Prom. Eng. Ed.,* 1896, IV, pp. 70–100.

Removal of General Training Studies from the Engineering Curriculum. *Proc. Soc. Prom. Eng. Ed.,* 1896, IV, 260.

Practical Work in Surveying in the Michigan Mining School. *Proc. Soc. Prom. Eng. Ed.,* 1896, IV, 327–330.

Shop Practice in the Michigan Mining School, *Proc. Soc. Prom. Eng. Ed.,* 1896, IV, 343–346.

German and American Mining Schools. *The Engineering and Mining Jour.,* 1897, LXIII, p. 352.

Michigan College of Mines, Change of Name and Tuition for 1897–1898, July 19, 1897, pp. 4.

The Michigan College of Mines. *Trans. Am. Inst. Mining Eng.*, 1897, XXVII (pp. 16), 696–711.

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The Michigan College of Mines and The Upper Peninsula of Michigan. In *The Michigan Farmer*, 1897, XXXII, pp. 286, 287, October 16.

Ten Years Advance of the Michigan College of Mines. In *Mining Journal*, Marquette, Mich., 1897, October 21, p. 3

The Upper Peninsula of Michigan and the Michigan College of Mines. In *The Houghton County Progress*, 1897, Vol. V, No. 15, pp. 20, 21.

Catalogue of the Michigan College of Mines, 1896–1898, pp. 192, V tables, 1 map, 1 plate.

Early Introduction of Technical Studies in Schools of Mines. *Proc. Soc. Prom. Eng. Ed.*, 1911, XIX, pp. 437, 438.

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The Smaller Mining Schools. *The Chicago Journal of Commerce*, 1888, May 16, p. 11.

Michigan Mining School. *Portage Lake Mining Gazette*, 1888, XXIX, No. 30, p. 1.

The State Mining School at Houghton. Judge J. W. Stone, Michigan Bankers Association, 1891, July, pp. 64–69.

How "————" Would Reduce Taxes. *Portage Lake Mining Gazette*, 1888, XXX, No. 18, p. 1, November 1.

Mining School Alumni. *The Portage Lake Mining Gazette*, 1892, XXXIII, No. 45, p. 1, June 2.

The Mining School. *Portage Lake Mining Gazette*, 1894, XXXIX, No. 32, p. 2, February 8.

Mine School, Iron Ore, 1895, XVII, No. 824, p. 1, October 12.

The Michigan Mining School, Brainard T. Judkins. *Portage Lake Mining Gazette*, 1897, XXXVIII, pp. 1, 4.

College of Mines. *Portage Lake Mining Gazette*, 1898.

Historical Resume of the Michigan College of Mines. *The Daily Mining Gazette,* 1911, XII, pp. 1–3.

So far as the present writer has observed this is a fairly accurate history of the time from 1887 to 1899.

Michigan College of Mines, J. Parke Channing. *Engineering and Mining Journal,* 1911, XCII, pp. 346, 347, August 19.

In this paper Dr. Channing uses for some two thirds of his paper, material taken from President Wadsworth's article on the Michigan College of Mines, published in the *Transactions of the American Institute of Mining Engineers,* 1897, XXVII, pp. 696–711. He gives no credit for that work and one might easily think the work of upbuilding the institution was entirely his. The writer can testify that Dr. Channing had nothing to do with the formulating the rules, or the development of the School in any way from 1887 to 1899, beyond the Director once asking him about his needs in mathematics since graduating at Columbia.

The Engineer, 1916, Michigan College of Mines, 1915–1916. Foundation and Growth.

This is apparently written by some one who had but little knowledge of the real history of the College.

PITTSBURGH, PA.,
November 26, 1920.

THE TEACHING OF SURVEYING.

BY CLARENCE T. JOHNSTON,
Professor of Geodesy and Surveying, University of Michigan.

As time passes the engineer seems inclined to lose touch with people as he pursues his professional activities. This is undoubtedly true of the rank and file. There are individual exceptions. The great majority are employees who take orders, who perform the duties of the day and, during leisure hours, mingle with a society which does not necessarily acknowledge them as engineers. In the early days of his profession, the engineer was a marked man. People turned their heads to get a better view of him as he passed. He was in contact with men of many walks of life during much of his working day. He then had a chance to impress himself upon society. He failed to do so. As a result, he is now not recognized as a citizen among citizens. He is not entrusted with public office except under the pressure of extreme necessity in public business. He seldom sits with those who frame or administer our laws. He is an educated man—the man of the street admits this—but he has subtle defects, of which he may be unconscious, yet which stand out so prominently that even the simple and the innocent have knowledge of them. Why is it that engineers, regardless of character, personality, training, and experience, carry such a handicap of unpopularity in the field of public service? There may be reasons why the public should invariably choose a lawyer, a physician, or even a successful merchant rather than an engineer when some public honor is to be bestowed or a public duty is to be performed. These reasons may never be altogether clear to the engineer. He cannot reconcile himself to the situation, however, when a hackdriver, a barber, or a trench digger is

selected for a public office which has to do with engineering work.

The public has judged the engineer by the best known and most striking evidence. Judgment of this sort cannot crystallize except after the lapse of years. The engineer began his activities with surveying. He failed to protect his profession in the days of its youth. He permitted the speculator, the politician, and the cheap lawyer to impose upon him, and, what is worse, through his lack of courage or his indifference, or both, he permitted these elements to prey upon society. Surveying is an applied science. The engineer has yet to prove this to a society that is now skeptical, if not unfavorably prejudiced.

At least three unfortunate influences have seriously affected the teaching and practice of surveying. First: when courses in engineering—largely surveying—were first introduced into our universities, the conservative, academic element of that time accepted the innovation under protest both loud and deep. Surveying entered our schools of higher education against opposition that would have discouraged teachers of weak conviction. All of the early branches of engineering education seem to have thrived under oppression. Within a period of twenty years after their entrance into the university arena, several branches became bold enough to demand independence, and to wave a new flag in the faces of those who had feared the recognition of applied science only a short time before. Second: as the teaching of engineering approached the time when it was to assume an independent status among the older departments of our universities, the teachers thereof had become expert in other things aside from surveying, which because of their higher commercial value and their novelty, made a greater appeal to both instructor and student. Third: while these changes were taking place in our universities, the national government was surveying the public domain under the contract system, a system devised and supported largely for the benefit of land speculators

who coöperated closely with our law-makers at Washington. If surveying needed another blow to wreck it in the eyes of educators, freeholders and the public generally, the national government responded bravely at this critical time.

Regardless of neglect, the influences of commercialism, politics, and the ignorance of practitioners, surveying has persisted. It is a part of the curriculum of every school and college of engineering. It is also a general subject, interesting foresters, geologists and students of landscape design. Even the army and navy rely upon surveying to some extent and in times of war some peculiar courses come into being under the influence of those who, stimulated by sentiments of patriotism, shoulder any responsibility when the nation faces an emergency.

In the *Proceedings* of the Society for the Promotion of Engineering Education for 1916, pages 200 to 209 inclusive, will be found a somewhat incomplete discussion of surveying as it is taught at sixty-eight engineering colleges of the country. A study of the tables and diagrams accompanying that paper must convince the reader that surveying courses are outlined and offered by the several colleges without much regard for the logical sequence of topics or the essential requisites of a balanced study of the subject. Courses in surveying may be prescribed for freshmen, sophomores, juniors or seniors. There seems to be no place where the theory begins or ends insofar as content of courses is concerned. One college may oblige freshmen to pursue an extensive course in land surveying; another may provide instruction in railway surveying for sophomores. A perusal of college catalogs often leaves the reader in a haze of uncertainty and convinces him that teachers of surveying are individualists of an extreme type. Some of these employ surveying to illustrate the formulæ of trigonometry while others seem to have outlined required courses for reasons that doubtless are to remain departmental secrets. It must be admitted that but little thought has been given the essential prerequisites or

the orderly and systematic development of theory and practice such as we find in mathematics and mechanics.

A university stands for something that the trade school may ignore. Trade schools provide training for young men who do not aspire to become leaders in engineering. They may make some progress in practice if they are able to apply methods that give results, regardless of whether or not they fully understand the theory which supports the rules they employ. They fill a place in the great field of industry that does not appeal to the more ambitious young man who is to forge ahead because of his command of fundamentals.

Courses in engineering should be so outlined that from the work of the preparatory schools, theory and practice may develop without a break, thus enabling students to find support on foundations laid by studies that have preceded. Because of the great demand for engineers and because many of the teachers of professional branches of engineering seldom realize that the successful practitioner depends largely upon his command of fundamentals, rather than because of expertness in matters distinctly professional, many elementary subjects have been weakened or they have entirely disappeared from required courses of study. Engineering education has degenerated as trade school methods have been substituted for university training. Engineering schools have too generally accepted the theory that any successful engineer is an authority on engineering education and immediately qualified to teach. When engineers first undertake these new duties, they only see professional features of engineering education. As their experience grows, they gradually discover that the young men they are teaching are very like themselves and their classmates while students and that the mastery of fundamentals is the important feature of engineering education. They find that it is unnecessary to teach surveying to freshmen in order that these immature students may find inspiration in the more elementary studies they should pursue. All problems in mathematics may be related to pro-

fessional work if desired. Surveying offers opportunities for illustrations of this kind, but the study of surveying should follow the completion of certain essential fundamentals. The teacher of trigonometry, analytical geometry or calculus may easily get into touch with teachers of engineering subjects and thus obtain illustrations and problems without limit from the field of practice. How far this should go remains to be seen. Mathematics applies to many things besides engineering and to many branches of engineering that teachers cannot foresee.

We deplore the lack of cultural values in engineering courses, yet we are inclined to arbitrarily extract all such qualities from the "courses for engineers" and place them on a strictly shop basis. Mathematics, as taught in some colleges of engineering, merely provides handles for professional tools, much of the philosophical and cultural values having been carefully removed. The teaching of English has been brought to an equally low level here and there where students are insulated from good English literature by specialization in report writing and the phraseology of business. The study of foreign language has frequently been deadened by the translation of technical papers when students might have been inspired by reading a little of the best literature of the language. Drawing courses for students of engineering have but little relation to art. There are cultural values in properly balanced courses in surveying. More care should be manifested in the preservation of those qualities that inspire students, thus providing the best guarantee for effective leadership in future practice.

Where consulting engineers, rather than teachers, dominate engineering colleges, fundamentals are likely to be slighted in favor of studies that relate to specialized practice. The administrators of these colleges may not awaken to the dangers which threaten until they compare modern requirements with those of twenty or more years go. An investigation may show that several miniature colleges have grown up within the parent organization and that professional depart-

ments have extended their tentacles to the work of the sophomore or even the freshman year. To illustrate, the original departments of drawing may have practically disappeared and all of the cultural values of the early courses therein may have been eliminated. Students may be required to obtain their instruction in drawing under young teachers representing the professional departments who can teach only in a mechanical way. They know nothing of drawing as an art. Professional departments may perfect an offensive and defensive alliance and stand together in support of a practice of this kind. When some young man who teaches drawing, shows ability in a professional subject, he may be promoted, and then another young man of equally limited experience assumes the responsibilities thus abandoned. Drawing is thus in the hands of cub instructors all of the time and promotions only come to them as they are advanced through the professional machine. This unfortunate practice is inclined to extend into every fundamental department. A subtle process for wrecking fundamental departments is for those in authority to drop courses formerly required. In a few years the teachers of the fundamental subject become so much discouraged that they resign or fall into a limited routine where they may be ignored and then the courses are restored with cultural values eliminated and taught by another group of cub instructors of the professional departments. Under such a system fundamental courses become lifeless and uninspiring. Teachers of these subjects are simply waiting the time when their terms of probation are ended. They do not plan to perfect themselves in the teaching of fundamentals. Their only chance for promotion is to be found in professional branches where better salaries are paid and where more opportunity is afforded for private practice. The teaching of surveying is seriously affected where such an administration develops.

Our country suffers because it has been practically denied the judgment of technical minds in the formulation and ad-

ministration of laws which relate to the engineering phases of public business. All engineers, and especially civil engineers (who have unusual responsibilities) have failed to support measures and principles which intimately concern themselves and the public. They have thus neglected obligations which rest upon every group of specially trained citizens. Public business must be transacted in some manner. As long as engineering judgment is not available, men of other walks of life must assume responsibilities that are foreign to their training and experience, and while this continues public business must suffer. Under such conditions engineers and surveyors are discredited in the eyes of other men and the work that they should defend falls into a distressing state of decay. For many years teachers of civil engineering witnessed a shameful waste of public money in highway construction without raising a voice in protest. What influence brought about the establishment of state highway departments? What interest have departments of civil engineering assumed in the framing and administration of drain laws? To what extent are our departments of civil engineering concerned in the administration of water resources, riparian boundaries, here or abroad, and what influence have they exercised within the states relative to better laws and better administrations? These departments have certainly never stimulated any great interest in laws which guarantee some protection to freeholders when boundary surveys are made. Are we to continue this passive attitude toward public business or will some more altruistic element come forward and assume the responsibilities that teachers of engineering have thus far ignored? Where shall we look for intelligent leadership if not at our state universities? If the teacher of civil engineering is to continue as a mere technical machine, concerned only in design, construction, and compensation, we should accept him at his own appraisal and then find or develop a new element which will render the service that the civil engineer performs in many foreign countries. It is

becoming more apparent to thinking men that a deep-seated public interest is the first essential of patriotism. Engineering colleges manifest motives that are unselfish when they stand for a type of education that the trade school cannot provide. Several important branches of surveying will continue to be a reproach to the engineering profession if some active group of well trained men does not soon come to the rescue.

Teachers of civil engineering often forget how broad the field of practice has grown. They also fail to realize that the great majority of students are to achieve success through the application of fundamentals rather than in activities that are exclusively professional. The civil engineer who becomes a specialist often forgets that he uses but a few branches of surveying. His associates and friends may employ entirely different branches, yet if they have all received a general training in surveying they will find their work supported, however varied or specific it may be. The majority of civil engineers have received a little instruction in what is commonly known as land surveying. But few practice therein and but few teachers of civil engineering would find it a simple matter to prepare specifications which would govern the survey of a tract of land so that when the work were finished, permanent monuments would mark corners, so that distance between monuments and the astronomical azimuth of lines would be determined within the least reading of the transit, so that a record would be made in some public office indicating what has been done in field and office and the freeholder furnished a map which would show the results of the survey, including the area actually in his possession. When work of this kind is governed by regulations based on science it must be performed by men qualified to render a high type of service. Such men reflect credit on the profession and on the educational institutions which provide them the necessary training. The accuracy of land or boundary surveys should not be proportioned according to the value

of lands any more than the safety of a bridge should vary with its cost. No person who represents applied science is to permit his reputation to fluctuate with real estate values.

To be more specific and, possibly, more constructive. The teaching of surveying is in a chaotic condition. Students who go from one school to another during their undergraduate years encounter some difficulties when they try to have their surveying credits adjusted. No engineering subject is in worse condition. Engineering educators have never assembled for the purpose of analyzing surveying as a study and then trying to reach an agreement as to how it should be taught. It is frequently entangled with courses in civil engineering or used as an illustration of some more elementary subject. As an independent study of general importance and a most ancient and honorable branch of engineering, now grievously abused, it has never had thoughtful consideration.

Surveying may be divided into five or more classes. The first class would include the elementary theory and practice which immediately underlies engineering operations. A little thought will enable one to bring together several branches that are included, in a more or less haphazard way, under departments of civil engineering, but which should be incorporated in class one. Railway surveying, or engineering, would be thought of at once. Highway surveying would now be considered as another and surveys for bridges, tunnels, canals, drains, river and harbor improvements, city surveys (exclusive of the platting of additions and original town sites), irrigation works, water power development, and buildings of the type that are designed and erected under engineering supervision would fall into the same category. There are other branches belonging to this class, but the list given will identify them and the teacher should have no trouble with the classification.

Class two would relate to topography, a great field stand-

ing almost alone and interesting engineers, geologists, military officers, landscape designers and foresters.

Class three would include boundary surveys, more commonly known as land surveying. This is one of the most important branches of surveying and to date the most abused. Generally speaking, no college prepares young men for this service. But few engineers qualify therefor even after many years of experience. It requires as much judgment and ability, assuming the work to be performed on a scientific basis, affording protection to the employer and the public and reflecting credit on the practitioner as any other single branch of applied science. No country exhibits such a sad spectacle as ours in this field of cadastral surveying. The Latin-American Republics to the south and Canada to the north afford object lessons which should inspire us to better things. We might well extend our interest and study beyond the limits of our own communities and beyond the pages of texts that support a practice that should be condemned. If engineers are to be charged with any further responsibility in this field they should face about and improve it immediately. If they are pleased to proceed under the handicap that they have been carrying, a large element of society will continue to judge engineering and engineers according to the standards applied to boundary surveys. Here is a back alley that should either be cleaned up or it should be delivered over to some element having more self-respect and possibly more stamina. Boundary surveying is always public work. Its present condition is a sad reflection on engineering education and engineering practice in this country. A few elementary signs of professional pride should have been manifested within the past sixty years.

Class four would embrace geodesy and its applications to the more elementary branches of surveying.

Class five would include riparian boundaries, such laws as the Torrens Act, court decisions relating to surveying and the history of departments which have to do with surveying

in this country and abroad. This field is surprisingly large and many courses would have to be offered to cover it in an approximate way.

Courses of class one should be preceded by mathematics, elementary drawing, and physics. To teach surveying to students unacquainted with physics is something like teaching structural engineering to students innocent of a knowledge of mechanics. Instruction of that kind belongs to a trade school. Numerous applications of the laws of physics will be found in properly constituted courses in surveying. Students who have completed thorough courses in physics know how unreliable the magnetic compass is when employed to determine direction; they know something about the theory of the vernier; they understand something of the laws of refraction and gravitation; they realize that the expansion of metals may introduce serious errors where instrumental methods are employed; and they have some appreciation of the combinations of lenses in surveying instruments. Students are not prepared to begin elementary courses in surveying until they have completed the study of analytic geometry, because the entire theory of traverse computations and many other problems in boundary surveying are simplified by a knowledge of coördinates, the straight line and the simple conic curves.

Other engineers than those pursuing courses in civil engineering may need but a brief course in surveying, preparing them for very elementary work such as staking out of buildings, the setting of machinery, the alignment of shafting and some simple work with the level. Although these men may perform simple exercises with surveying instruments they can only become familiar with the external and superficial features of the transit and level.

Students of civil engineering have broader responsibilities. They cannot be presumed to qualify as a group in more than the elementary branches. Following a drill in the use of instruments, the required work should support the more common branches of civil engineering. In order that the

courses may be properly balanced and to provide something in the way of essential fundamentals, they should embody the elements of triangulation, topography, cross-section work, boundary surveys, the adjustment of instruments, railway, canal, drain and highway surveying, base line measurement, and a little regarding astronomical azimuths and hydrographic surveying. This means that for students of civil engineering the required courses should be so laid out that the work of class one would be supplemented by the essential fundamentals of other classes. A few students of civil engineering might elect courses which go into more detail. The required courses simply support the common fields of civil engineering. They would provide only a foundation for those who plan to practice in the broader fields of surveying.

The engineer who makes a survey for a drain, a railway, a waterpower plant, a transmission line, a canal or a highway may be obliged to apply principles which are not involved in the field work connected directly with these engineering activities. Each is likely to demand surveys for rights of way. This means that monuments must be set and existing surveys connected with the lines established in support of the new development. A knowledge of topographic surveying is likely to be required. Accurate direction determined by astronomical methods is now demanded, where only a few years ago the compass was relied upon, or the entire survey based on assumed azimuths taken from existing lines between well established monuments. Assumed azimuths generally spell incompetency. Extensive works such as notable bridges and city surveys demand a knowledge of triangulation.

In order that such courses may be profitably pursued, students should have a knowledge of elementary practical astronomy, which in turn, rests upon spherical trigonometry. Students of civil engineering will find a knowledge of least squares helpful if not essential in triangulation work and the same theory would apply in the treatment of many other kinds

of engineering data. The study of calculus should precede the election of courses in least squares and advanced astronomy. Before students begin the study of topography they should have completed considerable work in drawing which is generally required. Departments of surveying have been much imposed upon by having to accept students unqualified in fundamental subjects. Of recent years fundamental courses have lost their breadth in many schools and they are now largely directed in support of certain phases of mechanics.

Students of civil engineering may acquire an elementary training in surveying by pursuing two courses of about four hours each at the college, followed by a course of at least eight weeks at a camp. The camp work should be devoted to a brief review of theory and to general application thereof in practice. This limited drill is effective only where the essential fundamentals for each course are concluded before their application is called for. Even when students of civil engineering have completed such courses they should not be considered as competent, independent practitioners excepting in connection with surveys of limited scope. Wherever surveys are more involved such practitioners should always have competent supervision.

The student of civil engineering would not be regarded as an expert in topographic surveying until after he has completed special courses therein and then obtained some years of first class practical experience. Boundary surveying is much more exacting. Students should complete courses which would embrace a total credit of from eighteen to thirty-five hours and then practice under competent supervision for several years before they should be considered as safe, independent practitioners. It is plain that the civil engineer will seldom qualify in boundary surveying. He should understand enough about boundary surveying to qualify him to perform field work of a simple nature and to enable him to know when to call for more expert aid. Under the courses

just described the student of civil engineering devotes something like one sixteenth of his time for sixteen weeks to boundary surveys. But few students will be able to pursue courses in geodesy, yet all civil engineers should know something as to the form of the earth. They should be familiar with parallels of latitude and meridians of longitude. They should know that meridians converge as the latitude increases. They should know how to correct azimuths as surveys are extended east or west at any latitude. They should know when they have reached their limitations in triangulation work either because of spherical excess or because of complicated applications of the theory of least squares. Students of civil engineering should not be considered as experts in practical astronomy. They are only prepared to perform such simple field operations as may be involved in an incidental way with surveys which relate to development or construction. The average student of civil engineering will continue to leave his university innocent of any knowledge of class five.

It is probable that graduates in civil engineering will not be able to qualify as surveyors hereafter any more than the civil engineer has heretofore acquitted himself with credit in the broader practice of surveying. It may be best that the student in civil engineering simply prepare himself in the elements of surveying as herein outlined, and that a new group be trained for the exacting practice which someone must soon assume. Whatever the decision may be, engineers generally have a common responsibility relative to surveying. Their political and social barometers will be high or low depending upon the impression that the engineer records in the field of surveying. Rare individuals may sparkle from an occasional cloud, but the profession at large has its feet on the ground and the surveyor, only, makes and protects this common foundation.

THE VALUE OF "g" IN ENGINEERING WORK.*

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Introduction.

The acceleration of gravity, called g, which is about 981 cm. per second per second or about 32 feet per second per second, often occurs in engineering computation. In many engineering measurements and formulæ, some of which are listed later, the proper numerical value of g must be used. It is well known that g varies very slightly from place to place on the earth's surface. The exact values will be here discussed from the point of view of the engineer. Corrections to take account of the variations, which vary from a quarter of a per cent. to a few thousandths of a per cent., are arrived at. For many purposes, such corrections are negligible and such are pointed out. The precise work where corrections are necessary is also pointed out, and exact correction data are given in convenient shape.

The measurements to be corrected depend upon the attraction of the earth upon a mass, often measured by the acceleration which it will give to any mass. For instance, pressures are measured in lbs./sq. in., which originally meant that there is a force on a square inch equal to the attraction of the earth on a certain standard mass defined as the "standard pound." It would not do to have units such as

* The author has had the privilege, while writing the article, of collaborating with the Coast and Geodetic Survey officials and with Professor E. V. Huntington, Associate Professor of Mathematics at Harvard, who is a recognized authority on the subject. The data given may, therefore, be considered authoritative. The present article is condensed from a longer one which includes corrections for refined physical work, published in the *General Electric Review*, May, 1918.

this vary from place to place with the attraction of gravity, so by recent universal consent in all such cases the force unit is taken as that giving the standard mass a particular acceleration, 980.665 cm./sec.^{2}

Standard Value of "g."

The value of g at any locality is measured by the acceleration of any freely falling body.*

It was early recognized that even though the variation from place to place was small, it was desirable for many reasons to fix upon a standard reference value.

For many years this was specified as being that at sea level, 45 degrees north latitude. As will be seen later, this is not an accurate specification, as the acceleration of gravity at sea level is somewhat different at different places on the circle of 45 degrees north latitude. Furthermore, the value which was originally assigned to the average at sea level 45 degrees north latitude has been shown by later measurements to be somewhat inaccurate. Hence, it is now universally agreed† that g_o, the standard value of the acceleration of gravity, is 980.665 cm. per second per second, or 32.1740 feet per second per second. This is the standard value until it is changed by international agreement, regardless as to whether it is the exact average value at sea level 45 degree N. Lat. It was supposed to be this at the time of adoption, but the latest work of the Coast and Geodetic Survey gives 980.621.‡

Of course the exact average value at sea level 45 degrees N. Lat. will be changed slightly by each large addition of new data, but this will not affect the arbitrary standard value.

* g is defined as "falling acceleration" by Professor E. V. Huntington, *Am. Math. Mo.*, Vol. 24, page 6, Jan., 1917.

† Procès-Verbaux des Séances, Comité International des Poids et Mesures, page 172, 1901. Bureau of Standards, Circular No. 34, 3d Ed., 1915, Relation of H.P. to KW., page 6.

‡ Page 134, Pub. No. 40, by Wm. Bowie.

Accurate Local Values of g.

Geodetic Bureaus of the governments of the United States and of many other countries have spent a great deal of time on measurements of the actual values of gravity at various points on the earth's surface and have established formulæ and theories regarding it. In the United States this work has been done by the United States Coast and Geodetic Survey, E. Lester Jones, present superintendent, and many exhaustive reports have been published.*

A rational formula can, of course, be deduced for the value of the acceleration of gravity for any latitude on a perfect ellipsoid of uniform density, and this gives the first approximation to the value of g at sea level. A simple rational formula called the "free air correction" can also be deduced for the effect of elevation above sea level, if we assume that we are located in free air at a distance above sea level without any intervening earth. The effect on the value of gravity at any point of actual earth between sea level and a given elevation; the effect of varying density of different geologic strata immediately under the point; the effect of plateaus, mountains, and sea depressions at a distance from the given point, etc., all make a very complicated problem.

*1. "Figure of the Earth and Isostasy from Measurements in the United States," by J. F. Hayford, 1909.

2. "Supplementary Investigation in 1909 of the Figure of the Earth and Isostasy," by J. F. Hayford, 1910.

3. "Effect of Topography and Isostatic Compensation upon the Intensity of Gravity," by J. F. Hayford and William Bowie (Special Publication No. 10), 1912.

4. Same title, second paper, by William Bowie (Special Publication No. 12), 1912.

5. "Investigations of Gravity and Isostasy," by William Bowie (Special Publication No. 40), 1917.

Résumé of all this work is given in special Publication No. 40, from which much of the following data are obtained. The writer is also indebted to Messrs. E. Lester Jones, A. A. Brooks, W. W. Johnson, R. L. Faris, Dr. H. N. Davis and Professor E. V. Huntington, for assistance in preparing this article.

It has been found that this problem is somewhat simplified by what is called isostatic adjustment. If the earth were a perfect fluid, but composed of materials of different density, there would be flow and adjustment of the different materials so as to give bulges or plateaus in regions where density was was less than average, and depressions or oceans in regions where density was greater than average. The earth is not nearly a perfect fluid, however, and this isostatic adjustment is not at all complete. The theory of this matter of isostasy cannot be discussed here. It will be sufficient to state that it gives a rational correction to the simple formulæ mentioned above. In the present state of the subject, even this correction, called isostatic compensation, does not quite give the actually observed values of gravity. The departure of an observed value from a computed value is called an anomaly. The Coast and Geodetic Survey publications above mentioned give complete details for computation by several different methods of corrections to the formulæ given, together with the anomaly for 219 gravity stations in the United States and many in other parts of the world.*

Actual Values of g in the United States.

The rational computations are quite complicated, and even when they are made, in order to get exact results, the anomalies must be taken into account. For very precise work we use values computed by a general formula corrected for elevation, and group all of the other corrections together as an anomaly which is to be obtained from a map.

There are two methods suitable for doing this, both starting with the Helmert 1901 formula for g_c† which is, in centimeters per second per second, for latitude ϕ, at sea level

$$g_c = 978.030\ (1 + 0.005302\ \sin^2\ \phi - 0.000007\ \sin^2\ 2\phi). \qquad (1)$$

* See the *General Electric Review* article for details.

† This is given on page 12 of publication No. 10 and page 49 of publication No. 40.

The Bouguer method, often employed, uses a correction for elevation which comes out $-0.000210\ H$ to $-0.000192\ H$, while the "free air" method uses the correction $-0.0003086\ H$ (H in meters). Both methods, of course, give the same results if the proper anomaly is used. However, the anomaly is small in either case and is frequently omitted. Hence, that method is preferable which gives the smaller average anomaly. This will be found to be the "Free Air Method"* which gives as the elevation correction to g in cm./sec.^{2}, $-0.0003086\ H$ or $-0.00009406\ H_f$ where H_f is in feet.

The Bouguer formula gives as a mean value for the latter constant, the much lower value -0.0000588. This is traditionally used as the proper elevation correction, but the data here given show that it is inaccurate.

When the "Free Air Method" is used the anomaly is negligible for engineering purposes and no map is needed and the tables in this article are arranged on that basis. Table I gives the final value of the correction factor for various latitudes and altitudes to reduce to the standard value of g 980.665 cm./sec.^{2} or 32.1740 ft./sec.^{2}, with more than sufficient accuracy for engineering. Each engineering laboratory should find the proper correction from this table, and use it in all cases where the desired precision warrants.

The correction for latitude has a maximum value of about fourteen-hundredths of one per ceht. (in the southernmost part of the United States).

The correction for elevation comes out about one one-hundredth of one per cent. per one thousand feet elevation.

The anomaly read from the gravity contours on a map, comes out as a maximum about one one-hundredth of one per cent. around Pikes Peak, Lead, South Dakota, and Mt. Ham-

* This is shown by inspection of Figs. 13 and 14 of publication No. 40. The latter is by the "Free Air Method" and is the map in the *General Electric Review* article, and gives anomalies varying from -0.050 to $+0.120$. The former is by the Bouguer method and gives anomalies varying from -0.220 to $+0.040$. There are large negative values in mountainous regions, showing that the constant is numerically too small.

ilton, California, and never reaches more than about one-half of this value elsewhere, so that the map need not be used for engineering purposes, but only for precise physical work.

Reduction of Forces to Standard Values.

In all cases (samples of which are given in the next paragraphs) when a force of a pound (or gram) is used it is understood to be the "standard pound force."* This is a force giving the standard mass of 1 lb. (or gram) an acceleration of the standard value, $g_o = 980.665$. Gravity has this value at the earth's surface along a line near the northern boundary of the United States.

A "local pound force" is a force which would give the standard pound mass an acceleration equal to the local acceleration of gravity.

Whenever we measure forces by means of instruments which depend upon the attraction of gravity, we measure in local pounds and must reduce to standard pounds by using the correction factors given beyond.

Examples of this are as follows:

Platform scales or other scales with weights, used to measure power by means of a brake such as a Prony brake, electric dynamometer, or a water brake.

Platform scales, etc., used to measure fluid velocity by means of nozzle reaction.

Dead weight gauges which measure pressure in lbs./sq. in. by means of weighted pistons.

Mercury, water, or other liquid pressure gauges, either with a U with equal legs or with a reservoir and a single leg.

Testing machines used in testing materials.

Experimental thermodynamic measurements, such as measurements of specific heat where some force is measured by the

* The distinction between standard pound force and local pound force, originally suggested by Professor E. V. Huntington, (Bull. S. P. E. E., Vol. 3, pp. 678–689, June, 1913, and Vol. 5, pages 20–22, February, 1915), has been adopted by the Bureau of Standards (Bulletin No. 34, 2d and 3d editions, 1914 and 1915, page 7).

attraction of the earth on a mass. This is usually a pressure measurement, however, covered by the pressure measuring instruments above.

We may summarize by saying that the corrections given are required in all cases where *forces* are measured by beam balances or weight scales. The correction would also apply with change of sign in the improbable event that a spring balance was used for precise weighing. The corrections are not to be used for cases of weighing with weight scales nor for cases of force measured with springs which read standard pounds.

Notation for Correction Factor Formulæ.

g = actual value of gravity at any point, cm./sec.^{2}.
g_c = computed value of gravity per equation (1).
g_o = 980.665 cm./sec.^{2} or 32.1740 ft./sec.^{2}.
This is the standard value of gravity.
ϕ = latitude.
H_f = elevation in feet.

Deductions of Correction Factor Formulæ for the United States.

As already explained

$$g = 978.030\ (1 + 0.005302\ \sin^2\phi - 0.000007\ \sin^2 2\phi) - 0.00009406\ H_f.$$

To obtain the value of a force in standard pounds, we must multiply the value in local pounds as read from a weight scales by the factor g/g_o.
Now

$$g/g_o = 1 + (g - g_o)/g_o$$

Hence we multiply the reading of the weight scales by the factor $(g - g_o)/g_o$ and add the product to the reading.
We have

$$(g-g_o)/g_o = 978.030 \times \frac{0.005302}{980.665} \sin^2 \phi$$

$$- 978.030 \times \frac{0.000007}{980.665} \sin^2 2\phi$$

$$+ \frac{978.030 - 980.665}{980.665} - \frac{0.00009406}{980.665} H_f$$

or

$$(g-g_o)/g_o = 0.0052878 \sin^2 \phi - 0.0000069812 \sin^2 2\phi$$

$$- 0.0026870 - 0.000000095916 \; H_f.$$

This gives the final corrections for latitude and elevation given in Table I.

"g" IN FORMULÆ.

The fundamental formula which is the basis of all formulæ where g appears is

$$F = W \; a/g.$$

Here F is a force acting on a weight W and producing an acceleration a. Much has been written regarding the technicalities of this formula which it is not our purpose to discuss.

In all our cases we mean by weight the value W_o found by comparing a given body with the piece of metal called the "standard pound mass" by means of a beam balance or weight scales. (This has been called the "standard weight.") As already pointed out we mean by g the arbitrary value g_o. F is force measured in "standard pounds" as already defined. a is acceleration in ft./sec.^{2}. The fundamental equation then is

$$F = W_o \; a/g_o.$$

Hence, in all formulæ in which g occurs in connection with the standard units of the preceding paragraph, the value is understood as being g_o, which is 980.665 cm./sec.^{2} or 32.1740 ft./sec.^{2}, regardless of place. A few such formulæ are as follows:

All formulæ of mechanics giving general relations, such as

centrifugal force, $W_o r\omega^2/g_o$, kinetic energy, $W_o V^2/2g_o$, momentum $W_o V/g_o$, forces with respect to moving axes, etc. (This does not include formulæ giving accelerations or forces due to the attraction of the earth at a particular place referred to later.)

Formulæ for flow of steam and gases due to standard pressures.

Formulæ of thermodynamics giving relations between energy in thermal units, such as B.t.u., and mechanical units, such as foot-pounds. Included here are formulæ giving work done by steam, and velocity of steam, from values in "Steam Tables."

Gravity in Formulæ with Forces Due to Earth's Attraction.

In cases where g occurs in connection with falling bodies at a particular place, the local g or value at that place must, of course, be used.

Such cases are the direct formulæ for falling bodies at a particular place,

$$s = 1/2gt^2,\ v = gt,\ v = \sqrt{2\ gs}.$$

There must also be included formulæ such as that for the velocity of water due to a head H

$$V = \sqrt{2gH}.$$

Of course, velocity due to pressure p measured in standard pounds per square inch would use the standard g_o. We have, therefore,

$$V = \sqrt{2\ g_o p/D},$$

where D is density in lbs./cu. ft.

Definition of Horse Power.

The horse power was defined by Watt as being 550 foot-pounds per second without consciousness of the distinction

TABLE I.

Total Gravity Correction Factor to 1/100 of 1 Per Cent.

This is amply accurate for most physical work and more than accurate enough for engineering work. The table gives the total correction for latitude and elevation. There is no correction for anomaly for this degree of accuracy. We multiply the measurement of a force on a weight scales by the correction in the body of the table and add it to the reading. Note that the correction is usually negative.

H_f Elevation in Feet.	0.	1,000.	2,000.	3,000.	4,000.	5,000.	6,000.	7,000.	8,000.	9,000.	10,000.
N. Lat ϕ Degrees											
25	−0.0017	−0.0018	−0.0019	−0.0020	−0.0021	−0.0022	−0.0023	−0.0024	−0.0025	−0.0026	−0.0027
26	−0.0017	−0.0018	−0.0019	−0.0020	−0.0021	−0.0022	−0.0023	−0.0023	−0.0025	−0.0025	−0.0026
27	−0.0016	−0.0017	−0.0018	−0.0019	−0.0020	−0.0021	−0.0022	−0.0023	−0.0024	−0.0025	−0.0026
28	−0.0015	−0.0016	−0.0017	−0.0018	−0.0019	−0.0020	−0.0021	−0.0022	−0.0023	−0.0024	−0.0025
29	−0.0015	−0.0016	−0.0016	−0.0017	−0.0018	−0.0019	−0.0020	−0.0021	−0.0022	−0.0023	−0.0024
30	−0.0014	−0.0015	−0.0016	−0.0017	−0.0018	−0.0019	−0.0020	−0.0020	−0.0021	−0.0022	−0.0023
31	−0.0013	−0.0014	−0.0015	−0.0016	−0.0017	−0.0018	−0.0019	−0.0020	−0.0021	−0.0022	−0.0023
32	−0.0012	−0.0013	−0.0014	−0.0015	−0.0016	−0.0017	−0.0018	−0.0019	−0.0020	−0.0021	−0.0022
33	−0.0011	−0.0012	−0.0013	−0.0014	−0.0015	−0.0016	−0.0017	−0.0018	−0.0019	−0.0020	−0.0021
34	−0.0010	−0.0011	−0.0012	−0.0013	−0.0014	−0.0015	−0.0016	−0.0017	−0.0018	−0.0019	−0.0020
35	−0.0010	−0.0011	−0.0011	−0.0012	−0.0013	−0.0014	−0.0015	−0.0016	−0.0017	−0.0018	−0.0019
36	−0.0009	−0.0010	−0.0011	−0.0012	−0.0013	−0.0014	−0.0015	−0.0015	−0.0016	−0.0017	−0.0018
37	−0.0008	−0.0009	−0.0010	−0.0011	−0.0012	−0.0013	−0.0014	−0.0015	−0.0016	−0.0016	−0.0017
38	−0.0007	−0.0008	−0.0009	−0.0010	−0.0011	−0.0012	−0.0013	−0.0014	−0.0015	−0.0016	−0.0017
39	−0.0006	−0.0007	−0.0008	−0.0009	−0.0010	−0.0011	−0.0012	−0.0013	−0.0014	−0.0015	−0.0016
40	−0.0005	−0.0006	−0.0007	−0.0008	−0.0009	−0.0010	−0.0011	−0.0012	−0.0013	−0.0014	−0.0015
41	−0.0004	−0.0005	−0.0006	−0.0007	−0.0008	−0.0009	−0.0010	−0.0011	−0.0012	−0.0013	−0.0014
42	−0.0003	−0.0004	−0.0005	−0.0006	−0.0007	−0.0008	−0.0009	−0.0010	−0.0011	−0.0012	−0.0013
43	−0.0002	−0.0003	−0.0004	−0.0005	−0.0006	−0.0007	−0.0008	−0.0009	−0.0010	−0.0011	−0.0012
44	−0.0001	−0.0002	−0.0003	−0.0004	−0.0005	−0.0006	−0.0007	−0.0008	−0.0009	−0.0010	−0.0011
45	−0.0001	−0.0002	−0.0002	−0.0003	−0.0004	−0.0005	−0.0006	−0.0007	−0.0008	−0.0009	−0.0010
46	0.0000	−0.0001	−0.0002	−0.0003	−0.0003	−0.0004	−0.0005	−0.0006	−0.0007	−0.0008	−0.0009
47	+0.0001	0.0000	−0.0001	−0.0002	−0.0003	−0.0004	−0.0005	−0.0005	−0.0006	−0.0007	−0.0008
48	+0.0002	+0.0001	0.0000	−0.0001	−0.0002	−0.0003	−0.0004	−0.0004	−0.0005	−0.0006	−0.0007
49	+0.0003	+0.0002	+0.0001	0.0000	−0.0001	−0.0002	−0.0003	−0.0004	−0.0005	−0.0005	−0.0006
50	+0.0004	+0.0003	+0.0002	+0.0001	0.0000	−0.0001	−0.0002	−0.0003	−0.0004	−0.0005	−0.0006

between standard and local foot-pounds. To obtain the exactness which is our present object, there must be an additional specification. An exact definition has been adopted by the Bureau of Standards* which has been in some use for many years. This makes the horse power equal to 746 watts. A watt is 10^7 times the power of an erg per second. An erg is a dyne acting through a cm. (0.3937 inches). A dyne is a force which gives a gram an acceleration of a centimeter per second per second.

TABLE II.

SAMPLE COMPUTATION OF TOTAL CORRECTION FACTOR TO 1/100 OF 1 PER CENT. FROM TABLE I.

Place	Lynn	Schenectady	Deming
Latitude, ϕ	42° 28′	42° 45′	32° 30′
Elevation, feet, Hf	20	235	4320
Total correction factor from Table I	−0.0003	−0.0003	−0.0016

A standard foot-pound per second is the work done per second by a force of a standard pound acting through a foot. A standard pound is a force which gives a pound (453.59 grams) an acceleration of 980.665 cm. per second per second. Hence there are

$$\frac{746 \times 10^7 \times 0.3937}{980.665 \times 453.59 \times 12} = 550.22$$

standard foot-pounds per second in a horse power. The Bulletin referred to shows that this gives 550 London foot-pounds where Watt made his original definition.

* Bulletin 34, "Relation of Horse Power to Kilowatt." E. V. Huntington, BULL. SOC. FOR PRO. ENG. ED., Vol. 5, 1915, page 20.

EDITORIAL.

Do the Electric Railways Need any More Technical Graduates?*—This time of the year the prospective five thousand graduates, more or less, of a hundred technical schools are beginning to wonder what they are going to do after commencement. Already the manufacturing and some other industries are planning to send representatives to the colleges to explain to the young men, and young women too in some cases, the attractions of their several fields of activity. The electric railways will not be so represented. This is partly because there is no central organization for the electric railways which takes up matters of this kind, and individual railways do not need enough men to warrant them in going to the expense of sending "scouts" to the colleges. It is doubtful, also if the value of a technical education applied to the right kind of an individual is appreciated as much in the railways as in manufacturing. Possibly the value is actually higher in the latter field but this ought not to be so.

At any rate, the manufacturers and a few others will get the choice of the educational crop and the railways will take what is left, including, however, those young men who have heard the "call of the rail" and will insist on going into transportation work in spite of lack of invitation and even, if necessary, of opposition. Luckily, this number is considerable.

There are many excellent opportunities for technical graduates in the electric railway and related fields. The whole business is founded upon civil, mechanical, and electrical engineering. Of course, the focus of interest has shifted somewhat in recent years from track, power plant and line, to

* This editorial is reprinted from the *Electric Railway Journal*, and was submitted by Henry H. Norris, managing editor, formerly secretary of this society.

fares, schedules, accident reduction, etc., but fundamentally transportation is a proposition of moving people and goods from one point to another with a maximum of speed, economy and safety. As long as this is so the business will need engineers.

Furthermore, the principles underlying engineering have application far outside the engineering divisions of the field and engineers are making themselves useful in the transportation, purchasing, accounting and other departments. They are especially useful in the making of appraisals, either on the railway organization or without, a phase of the work which is bound to become more and more important.

It is too bad that some systematic way has not been provided by which the electric railway field can be explained to engineering students. Some schools have courses in transportation engineering, which serve an excellent purpose, but they need to be supplemented by talks from competent railway executives or their representatives. This would seem to be a line of work for the American Electric Railway Association and American Railway Association to take up on behalf of their respective clienteles.

OBITUARY.

John Robins Allen was born in Milwaukee, July 23, 1869, and received his preparatory education at Milwaukee and at Ann Arbor, Michigan. He was graduated at the University of Michigan with the degree of B.S. (M.E.) in 1892, receiving his M.E. degree from the same institution in 1896. For one year he was connected with the Bay City Industrial Works, and for two years, with the L. K. Comstock Construction Company of Chicago. Since that time he has been connected with educational work as follows:

Mechanical Engineering Department, University of Michigan, as Instructor, Assistant professor, Junior professor, and professor of Mechanical Engineering, 1896–1911.

Dean of the Engineering Department, Robert College, Constantinople, Turkey, 1911–1913.

Head of the Mechanical Engineering Department, University of Michigan, 1913–1917.

Dean, College of Engineering and Architecture, University of Minnesota, 1917–1919.

Director of Research Bureau of American Society of Heating and Ventilating Engineers, 1919–Oct. 26, 1920. Pittsburgh, Pa., U. S. Bureau of Mines.

Past-President, The American Society of Heating & Ventilating Engineers.

Past-President, Michigan Engineering Society.

Past-President, Michigan Chapter, American Society of Heating & Ventilating Engineers.

Member, British Institute of Heating and Ventilating Engineers.

Vice-President, American Society of Mechanical Engineers.

Member, Society for the Promotion of Engineering Education.

Member of Honorary Societies, Ta Beta Pi and Sigma Xi & Alpha Kappa Sigma.

Honorary Member, National District Heating Association.

He is a joint author of a book on Heat Engines, published by McGraw-Hill Co., also joint author of "Heating and Ventilation," published by McGraw-Hill Co., and author of "Notes on Heating and Ventilation" published by Domestic Engineering.

COLLEGE NOTES.

The University of Wisconsin.—*Department of Electrical Engineering.* DR. JAMES THERON ROOD has been appointed Professor of Electrical Engineering in this department. Professor Rood was graduated in electrical engineering from Worcester Polytechnic Institute in 1898. After five years of engineering experience in the electric railway and manufacturing field, Professor Rood held, for three years, a fellowship at Clark University, receiving the degree of Doctor of Philosophy in 1906. From 1909 to 1918, Professor Rood was Head of the Department of Electrical Engineering at Lafayette College, Pennsylvania, and from 1918 to 1920 was Professor of Railway Electrical Engineering at the University of Illinois. Professor Rood's consulting engineering practice has been largely in the electric railway and central station fields.

Steam and Gas Engineering Department.—JOHN M. GALLALEE appointed Associate Professor of Steam and Gas Engineering. Professor Gallalee was graduated from the University of Virginia in 1911. He served for a time as instructor at that University, and later as Professor of Mechanical Engineering at the University of Alabama. While in the latter position, he acted, also, as engineer for the Alabama Power Co., The Central Iron & Coal Company, and as consulting engineer for certain projects of the Engineer Corps, U. S. A.

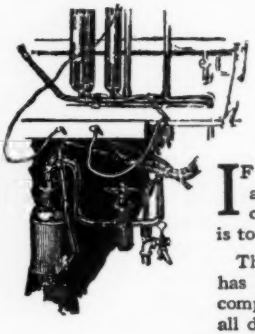
ARTHUR HENRY ANDERSON appointed as Assistant Professor of Steam and Gas Engineering. Professor Anderson was graduated from the Armour Institute of Technology in 1902, and received the M.E. degree from the same institution in 1905. From 1905 to 1919, he was on the teaching staff of Armour Institute in the Experimental Engineering Department. For the past year, Mr. Anderson was testing engineer for W. A. Blonck & Co., of Chicago. During his professor-

ship at Armour Institute, he has also acted as consulting engineer in a large number of tests for industrial concerns in that district.

Chemical Engineering Department.—O. A. HOUGEN appointed an Assistant Professor of Chemical Engineering. Mr. Hougen is a graduate of the University of Washington in 1915, and was Instructor in Chemical Engineering at this institution in 1917–18. For the last two years, he has been in commercial practice, the past year being spent with the Carborundom Company at Niagara Falls as research chemist.

Mechanics Department.—RAYMOND ROARK appointed as Assistant Professor of Mechanics. Mr. Roark was graduated from the University of Illinois in 1911, and was instructor in mechanics at The University of Wisconsin from 1913 to 1917. He then served in the First Division, Field Artillery, as Captain, and for the past year has been on the faculty of the University of Iowa.

Machine Design Department.—A. A. NEFF appointed as Assistant Professor of Machine Design. Mr. Neff graduated from the University of Nebraska in 1910. Since graduation, he has served as instructor in Purdue University, and, more recently, as instructor in the Mooseheart (Illinois) Industrial School, where he had charge of designing, equipping, and organizing the work in machine shop practice.



What Is Vacuum?

IF THE traffic policeman did not hold up his hand and control the automobiles and wagons and people there would be collisions, confusion, and but little progress in any direction. His business is to *direct*.

The physicist who tries to obtain a vacuum that is nearly perfect has a problem somewhat like that of the traffic policeman. Air is composed of molecules—billions and billions of them flying about in all directions and often colliding. The physicist's pump is designed to make the molecules travel in one direction—out through the exhaust. The molecules are much too small to be seen even with a microscope, but the pump jogs them along and at least starts them in the right direction.

A perfect vacuum would be one in which there is not a single free molecule.

For over forty years scientists have been trying to pump and jog and herd more molecules out of vessels. There are still in the best vacuum obtainable more molecules per cubic centimeter than there are people in the world, in other words, about two billion. Whenever a new jogging device is invented, it becomes possible to eject a few million more molecules.

The Research Laboratories of the General Electric Company have spent years in trying to drive more and more molecules of air from containers. The chief purpose has been to study the effects obtained, as, for example, the boiling away of metals in a vacuum.

This investigation of high vacua had unexpected results. It became possible to make better X-ray tubes — better because the X-rays could be controlled; to make the electron tubes now so essential in long-range wireless communication more efficient and trustworthy; and to develop an entirely new type of incandescent lamp, one which is filled with a gas and which gives more light than any of the older lamps.

No one can foretell what will be the outcome of research in pure science. New knowledge, new ideas inevitably are gained. And sooner or later this new knowledge, these new ideas find a practical application. For this reason the primary purpose of the Research Laboratories of the General Electric Company is the broadening of human knowledge.

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"At that, we engineers are lucky. If you don't believe it ask any lawyer or doctor what his first five years were like.

"That's the way I reasoned it out, and I decided to stick. I had chosen engineering not as a makeshift job, but as a life work that any man could be proud of. And if you can judge the future of this profession by its past and present, here's a game that is certainly worth the candle.

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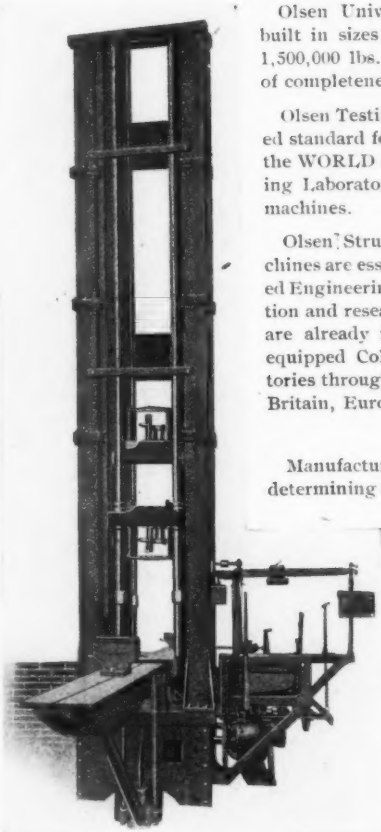

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The Bulletin is the official organ of the Society. It is published monthly from September to June. It contains not only the text of papers presented before the Society, but also college notes, short contributions from members, and matters of general interest to all persons connected directly or indirectly with technical education.

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